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Patent Application for

LOCALLY POWERED WATER DISTILLATION SYSTEM

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[0001] The present application claims priority from US Provisional Patent Applications 60/425,820, filed November 13, 2002, and 60/490,615, filed July 28, 2003, as well as from US Provisional Patent Application, Serial No. ___________, entitled "Locally Powered Water Distillation System," filed November 10, 2003, all of which applications are incorporated herein by reference. Concurrently filed US Application No. 10/_______, entitled "Pressure Vapor Cycle Liquid Distillation," is also incorporated herein by reference.

Technical Field

[0002] The present invention pertains to systems and methods for distributed utilities, and, more particularly, to providing distributed water purification systems using power and heat output from external combustion heat engines.

Background Art

[0003] A dependable source of potable water eludes vast segments of humanity, the Canadian International Development Agency reporting that about 1.2 billion people lack access to safe drinking water. A person must depend, for a supply of clean water, on proximity to uncontaminated natural sources, or must otherwise have access to a dependable common system of publicly treated water, or else dependable supplies of chemical purifying agents or power sources for distillation, none of which are typically available in much of the developing world. Consequently, an integral and reliable source of treating water, whether for medical purposes, for human consumption, or otherwise, that is robust, efficient, and requires only readily available materials is very desirable. As used herein, and in any appended claims, the term 'purifying' refers to substantially reducing the concentration of one or more contaminants to specified levels or otherwise substantially altering the concentration of one or more substances to specified levels. The term 'specified levels' refers to some desired level of concentration, as established by a user for a particular application. One instance of a specified level may be limiting a contaminant level in a fluid to carry out an industrial or commercial process. An example

is eliminating contaminant levels in solvents or reactants to a level acceptable to enable an industrially significant yield in a chemical reaction (e.g., polymerization). Another instance of a specified level may be a certain contaminant level in a fluid as set forth by a governmental or intergovernmental agency for safety or health reasons. Examples might include the concentration of one or more contaminants in water to be used for drinking or particular health or medical applications, the concentration levels being set forth by organizations such as the World Health Organization or the U.S. Environmental Protection Agency.

[0004] Distributed water purification systems, such as described in US Provisional Application 60/425,820 and concurrently filed US Application No. 10/_______, entitled "Pressure Vapor Cycle Liquid Distillation, and distributed electrical generators, such as diesel-powered internal combustion generators and generators based on the Stirling cycle, such as described in U.S. Patent No. 6,253,550, may be used to provide electricity and safe drinking water without the expense and delays associated with building and maintaining utility plants and the infrastructure required to bring the electricity and safe drinking water and to its point of use. With the use of such distributed utilities, however, comes the need to appropriately distribute these utilities to the people who need them and to monitor the operation and correct usage of these systems.

Summary of the Invention

[0005] In accordance with preferred embodiments of the present invention, there is provided a method for removing contaminants from water. The method has a first step of driving an electric generator by means of a thermal cycle engine for generating electrical power capacity, the thermal cycle engine including a burner for combusting a fuel. The method has further steps of employing at least a portion of the electrical power capacity of the electric generator for powering a water purification unit, supplying source water to an input of the water purification unit, and conveying heat output of the thermal cycle engine for supplying heat to the water purification unit. In a specific embodiment, the water purification unit can be a vapor compression distillation system. In such case the method may additionally have the steps of vaporizing the untreated water and condensing the vaporized water into a distilled water product.

[0006] In accordance with further embodiments of the invention, the step of conveying heat output may further include transferring heat from an exhaust gas of the burner to source water supplied to the water purification unit, and also heating an enclosure surrounding the water purification unit for reducing thermal losses.

[0007] In accordance with other embodiments of the invention, a method is provided for concentrating contaminants removed from water. The method has steps of:

a. driving an electric generator by means of a thermal cycle engine for generating electrical power capacity, the thermal cycle engine including a burner for combusting a fuel;
b. employing at least a portion of the electrical power capacity of the electric generator for powering a water purification unit;
c. supplying source water to an input of the water purification unit;
d. conveying heat output of the thermal cycle engine for supplying heat to the water purification unit;
e. vaporizing the untreated water; and
f. collecting contaminants removed from the water.

[0008] In accordance with yet further embodiments of the invention, a system is provided for purifying water that has a thermal cycle engine including a burner for combusting a fuel for driving an electric generator to generate electrical power capacity and a water purification unit powered by the electric generator. The system also has an input for receiving source water for purification by the water purification unit and a conduit for conveying heat output of the thermal cycle engine to the water purification. In a specific embodiment, the water purification unit can be a vapor compression distillation system.

[0009] In accordance with other embodiments of the present invention, a monitoring system for distributed utilities is provided. The monitoring system has a generation device for converting an available resource to a desired utility. The available resource may be water, in which case the generator is a purifier for providing potable water. Alternatively, the generator may convert a fuel to electrical power. In either case, an input sensor is provided for measuring one or more characteristics of the input to the generation device, while an output sensor is provided for measuring consumption or other

characteristic of output from the generation device. The monitoring system has a controller for concatenating measured input and consumption of output on the basis of the input and output sensors.

[0010] Where the generation device is a water purifier, the input sensor may be a flowrate monitor. The output sensor may be a water quality sensor including one or more of turbidity, conductivity, and temperature sensors. On the other hand, where the generation device is an electrical power generator, the input sensor may include a fuel consumption rate monitor and the output sensor may include an electrical usage meter.

[0011] The monitoring system may also have a telemetry module for communicating measured input and output parameters to a remote site, either directly or via an intermediary device such as a satellite, and, moreover, the system may include a remote actuator for varying operating parameters of the generator based on remotely received instructions. The monitoring system may also have a self-locating device, such as a GPS receiver, having an output indicative of the location of the monitoring system. In that case, characteristics of the measured input and output may depend upon the location of the monitoring system.

[0012] In accordance with further embodiments of the invention, a distributed network of utilities is provided, including sources of purified water and sources of electrical power. The distributed network has generators for converting a resource into a useful utility, input sensors for measuring inputs to respective generators, output sensor for measuring consumption of output from respective generators, and a telemetry transmitter for transmitting input and output parameters of a specified generator. Finally, the distributed network has a remote processor for receiving input and output parameters from a plurality of utility generators.

[0013] In accordance with yet another embodiment of the invention, a method is provided for supplying distributed utilities. The method has steps of providing a generator to a user, monitoring at least one index of generator usage to supply a utility, and charging the user on the basis of the index of generator usage.

Brief Description of the Drawings

[0014] The foregoing features of the invention will be more readily understood by reference to the following detailed description, taken with reference to the accompanying drawings, in which:

Fig. **1** shows the component power unit and water purifier unit in accordance with a preferred embodiment of the present invention;

Fig. **2** is a basic block diagram of a vapor compression water purification unit in accordance with embodiments of the invention;

Fig. **3** is a schematic diagram of a water purification unit in accordance with embodiments of the invention;

Fig. **4** is a schematic block diagram of an auxiliary power unit for providing electrical power and heat for water purification in accordance with the present invention;

Fig. **5** is a schematic overview of an integral power unit/water purification system in accordance with an embodiment of the present invention;

Fig. **6** is a depiction of a monitoring system for distributed utilities in accordance with embodiments of the present invention; and

Fig. **7** is a depiction of a distribution system for utilities in accordance with embodiments of the present invention.

Detailed Description of the Invention

[0015] The systems provided in accordance with embodiments of the present invention have two basic functional components that may be combined within a single integral unit or may be capable of separate operation and coupled as described herein for the purpose of local water purification. Fig. 1 depicts an embodiment of the invention in which a power unit **10** is coupled electrically, via cable **14**, to provide electrical power to a vapor compression water distillation unit **12**, with exhaust gas from the power unit coupled to convey heat to the water distillation unit via an exhaust duct **16**.

[0016] Use of an external combustion engine, such as a Stirling cycle engine, to provide mechanical power for conversion into electrical power by means of a generator is described in detail in US Patent No. 6,536,207 (Kamen et al.), issued March 25, 2003, and incorporated herein by reference.

[0017] Thermal cycle engines are limited, by second law of thermodynamics, to a fractional efficiency, i.e., a Carnot efficiency of $(T_H-T_C)/T_H$, where T_H and T_C are the temperatures of the available heat source and ambient thermal background, respectively. During the compression phase of a heat engine cycle, heat must be exhausted from the system in a manner not entirely reversible, thus there will always be a surfeit of exhaust heat. More significantly, moreover, not all the heat provided during the expansion phase of the heat engine cycle is coupled into the working fluid. Here, too, exhaust heat is generated that may be used advantageously for other purposes. The total heat thermodynamically available (i.e., in gas hotter than the ambient environment) in the burner exhaust is typically on the order of 10% of the total input power. For a power unit delivering on the order of a kilowatt of electrical power, as much as 700 W of heat may be available in an exhaust stream of gas at temperatures in the vicinity of 200°C. In accordance with embodiments of the present invention, the exhaust heat, as well as the electrical power generated by an engine-powered generator, are used in the purification of water for human consumption, thereby advantageously providing an integrated system to which only raw water and a fuel need be provided.

[0018] Moreover, external combustion engines, such as Stirling cycle engines, are capable of providing high thermal efficiency and low emission of pollutants, when such methods are employed as efficient pumping of oxidant (typically, air, and, referred to herein and in any appended claims, without limitation, as "air") through the burner to provide combustion, and the recovery of hot exhaust leaving the heater head. In many applications, air is pre-heated, prior to combustion, nearly to the temperature of the heater head, so as to achieve the stated objectives of thermal efficiency. However, the high temperature of preheated air, desirable for achieving high thermal efficiency, complicates achieving low-emission goals by making it difficult to premix the fuel and air and by requiring large amounts of excess air in order to limit the flame temperature. Technology directed toward overcoming these difficulties in order to achieve efficient and low-emission operation of thermal engines is described, for example, in US Patent No. 6,062,023 (Kerwin, et al.) issued May 16, 2000, and incorporated herein by reference.

[0019] External combustion engines are, additionally, conducive to the use of a wide variety of fuels, including those most available under particular local circumstances, however the teachings of the present description are not limited to such engines, and

internal combustion engines are also within the scope of the present invention. Internal combustion engines, however, impose difficulties due to the typically polluted nature of the exhausted gases, and external combustion engines are preferably employed.

[0020] Within the scope of the present invention, water purification system **12** may be embodied in various ways. A conceptual flow diagram of a vapor compression distillation unit in accordance with one possible embodiment of the present invention is shown in Figure 2, with liquid flow paths indicated by arrows. In an embodiment of this type, liquid flows through the system from an intake **00** into an exchanger **400** wherein exchanger **400** receives heat from at least one of a plurality of sources including a condenser **200**, a head **300**, and exhaust (not shown) from a power source such as an internal or external combustion engine. Liquid continues flowing past heat exchanger **400** into a sump **500** and into a core **600** in thermal contact with condenser **200**. In the core **600**, the liquid is partially vaporized. From core **600**, the vapor path proceeds into head **300** in communication with a compressor **100**, and from there into condenser **200**. After vapor is condensed, liquid proceeds from condenser **200** through heat exchanger **400**, and finally into an exhaust region **700** and then out as final distilled product.

[0021] Pre-treatment of the liquid to be distilled, typically water in the present application, occurs within intake **00**. Pre-treatment operations may include any or all of gross-filtering, treatment with chemical additives such as polyphosphates or polyaspartates, electrochemical treatment such as with an oscillating magnetic field or an electrical current, degassing, or UV treatment. As mentioned above, in one particular embodiment, a Stirling engine generator which produces exhaust high in CO_2 content is used as the power source **800** to power the overall system. In such an embodiment, the exhaust from the Stirling engine may be funneled back to intake **00** and used to acidify the water to be purified as one means of pre-treatment. Such acidification may, for example, reduce any scaling that might otherwise occur in the system.

[0022] One practical embodiment of the vapor compression still of Fig. 2 is shown in the schematic diagram of Fig. 3. A system in accordance with this particular embodiment, shown by way of example, has cold liquid intake **39** flowing through pump intake **00**, continuing through exchanger **400**. Pump **00** is typically a diaphragm positive-displacement pump, which is self-priming when the system is not pressurized – i.e., the

pressure inside the system equals the pressure outside. In a preferred embodiment, pump **00** may also have a loop feedback configuration, with air vent **01**, to help prime pump **00** upon start-up, or more particularly, to re-prime the operating system, under pressure, if the prime is lost, as would happen if the source hose were removed from the liquid source container.

[0023] From exchanger **400**, the intake line may continue in a cooling loop about motor **150**, and then continue into core evaporator/condenser **600** wherein condenser **200** has a top core plate **48** and a bottom core plate **50**. Within core evaporator/condenser **600** may be multiple parallel tubes **49**, typically made of copper-nickel alloy or other heat-transferable material, having head manifold openings **56** to allow core tubes **49** to communicate with head **300**, and having sump manifold openings **55** to allow tubes **49** to communicate with sump **500**. Steam **21** from the condenser section **600C** of evaporator/exchanger **600** may also feed into a volatile mixer **23** where volatile gases may be released from the system.

[0024] The system maintains a constant blowdown water flow to prevent scaling in the system. Water level **19** in head chamber **300** is adjusted through a feedback control loop using level sensor L1, valve V1, and source pump **00**, to maintain proper water flow through the blowdown stream **43**. The three-way source pump fill valve **29** is set to pump water into sump **500**, which causes water level **19** in head chamber **300** to rise. As liquid level **19** rises in head chamber **300**, liquid overflows past a dam-like barrier **302** into blowdown control chamber **301** containing product level sensor **L1**. As required, blowdown valve **V1** is controlled to allow water flow from blowdown control chamber **301** through heat exchanger **400**, to extract heat and cool blowdown stream **43**, and flow out valve **V1**, through volatile mixer **23** allowing cooling of hot gases and steam **21** from the condenser section **600C**, and then completing the blowdown stream, out to waste **43A**.

[0025] The system also maintains proper product flow. Product level **502** builds up in condenser chamber **600C**, and enters into product control chamber **501**, where product level sensor **L2** is housed. Using a feedback control loop with level sensor **L2** and valve **V2**, product stream **41** is controlled to flow from product control chamber **501** through heat exchanger **400**, to extract heat and cool product stream **41**, then through valve **V2**

and on out to complete the product stream as product water outlet **41A**. Furthermore, the system also maintains a proper liquid ring pump water level. Liquid ring pump control chamber **101**, which houses liquid ring pump level sensor **L3** used to control the liquid ring pump level, is fluidly connected to liquid ring pump **100**. Liquid ring pump **100** is connected to the three-way source fill valve **29**, which is set when the liquid ring pump requires more water and it is also connected to the liquid ring pump drain valve **V3**, which opens when it is required to drain water from liquid ring pump **100** into blowdown stream **43**.

[0026] As shown in Figure 3, there is additionally a steam flow line **22** from head **300** to compressor **100**, a steam outlet **57** for diverting steam to condenser **200**, a hot product line **41** from condenser **200** leading through exchanger **400**, which also allows for collection of hot purified condensed product in chamber **501** and a line (not shown) for diverting hot product to compressor **100** to allow adjustment of water level to keep it constant. There may also be a drain line (not shown), for when the system is shut down. Further, there may be a heater **900** with heating element **60** for heating cold liquid to boiling at start-up, and for maintaining sufficient heat during operation of the still to continuously convert liquid to steam. In one embodiment of the invention, the distillation system may operate at steady-state without thermal input from the heater **900** after system start up. Alternatively, a second heater (not shown) may be used to maintain sufficient heat during operation; the heater may run continuously, in a pulsed mode, or be controlled by a controller.

[0027] An embodiment of a power unit **10** is shown schematically in Fig. 4. Power unit **10** includes an external combustion engine **101** coupled to a generator **102**. In a preferred embodiment, the external combustion engine **101** is a Stirling cycle engine. The outputs of the Stirling cycle engine **101** during operation include both mechanical energy and residual heat energy. Heat produced in the combustion of a fuel in a burner **104** is applied as an input to the Stirling cycle engine **101**, and partially converted to mechanical energy. The unconverted heat or thermal energy accounts for 65 to 85% of the energy released in the burner **104**. This heat is available to provide heating to the local environment around power unit **10** in two forms: a smaller flow of exhaust gas from the burner **104** and a much larger flow of heat rejected at the cooler **103** of the Stirling engine. (Power unit **10** may also be referred to as an auxiliary power unit (APU).) The

exhaust gases are relatively hot, typically 100 to 300°C, and represent 10 to 20% of the thermal energy produced by the Stirling engine **101**. The cooler rejects 80 to 90% of the thermal energy at 10 to 20°C above the ambient temperature. The heat is rejected to either a flow of water or, more typically, to the air via a radiator **107**. Stirling cycle engine **101** is preferably of a size such that power unit **10** is transportable.

[0028] As shown in Figure 4, Stirling engine **101** is powered directly by a heat source such as burner **104**. Burner **104** combusts a fuel to produce hot exhaust gases which are used to drive the Stirling engine **101**. A burner control unit **109** is coupled to the burner **104** and a fuel canister **110**. Burner control unit **109** delivers a fuel from the fuel canister **110** to the burner **104**. The burner controller **109** also delivers a measured amount of air to the burner **104** to advantageously ensure substantially complete combustion. The fuel combusted by burner **104** is preferably a clean burning and commercially available fuel such as propane. A clean burning fuel is a fuel that does not contain large amounts of contaminants, the most important being sulfur. Natural gas, ethane, propane, butane, ethanol, methanol and liquefied petroleum gas ("LPG") are all clean burning fuels when the contaminants are limited to a few percent. One example of a commercially available propane fuel is HD-5, an industry grade defined by the Society of Automotive Engineers and available from Bernzomatic. In accordance with an embodiment of the invention, and as discussed in more detail below, the Stirling engine **101** and burner **104** provide substantially complete combustion in order to provide high thermal efficiency as well as low emissions. The characteristics of high efficiency and low emissions may advantageously allow use of power unit **10** indoors.

[0029] Generator **102** is coupled to a crankshaft (not shown) of Stirling engine **101**. It should be understood to one of ordinary skill in the art that the term generator encompasses the class of electric machines such as generators wherein mechanical energy is converted to electrical energy or motors wherein electrical energy is converted to mechanical energy. The generator **102** is preferably a permanent magnet brushless motor. A rechargeable battery **113** provides starting power for the power unit **10** as well as direct current ("DC") power to a DC power output **112**. In a further embodiment, APU **10** also advantageously provides alternating current ("AC") power to an AC power output **114**. An inverter **116** is coupled to the battery **113** in order to convert the DC power

produced by battery **113** to AC power. In the embodiment shown in Figure 1, the battery **113**, inverter **116** and AC power output **114** are disposed within an enclosure **120**.

[0030] Utilization of the hot exhaust gas generated in the operation of power unit **10** is now described with reference to the schematic depiction of an embodiment of the invention in Fig. **5**. Burner exhaust is directed through a heat conduit **16** into enclosure **504** of water purification unit designated generally by numeral **12**. Heat conduit **16** is preferably a hose that may be plastic or corrugated metal surrounded by insulation, however all means of conveying exhaust heat from power unit **10** to water purification unit **12** are within the scope of the present invention. The exhaust gas, designated by arrow **502**, blows across finned heat exchanger **506**, thereby heating the source water stream **508** as it travels to still evaporator **510**. The hot gas **512** that fills the volume surrounded by insulated enclosure **504** essentially removes all thermal loss from the still system since the gas temperature within the insulated cavity is hotter than surface **514** of the still itself. Thus, there is substantially no heat flow from the still to the ambient environment, and losses on the order of 75 W for a still of 10 gallon/hour capacity are thereby recovered. A microswitch **518** senses the connection of hose **16** coupling hot exhaust to purification unit **12** so that operation of the unit may account for the influx of hot gas.

[0031] In accordance with alternate embodiments of the invention, adding heat to exhaust stream **502** is within the scope of the invention, whether through addition of a post-burner (not shown) or using electrical power for ohmic heating.

[0032] During initial startup of the system, power unit **10** is activated, immediately providing both electrical power and hot exhaust. Warm-up of water purification unit **12** is significantly accelerated since finned heat exchanger **506** is initially below the dew point of the moisture content of the exhaust and since the exhaust contains water as a primary burner combustion product. All the heat of vaporization of this water content is available to heat source water as the water condenses on the fins of the heat exchanger. The heat of vaporization supplements heating of the fins by convection of hot gas within the still cavity. Heating of the fins by convection continues even after the fins reach the dew point of the exhaust.

[0033] In accordance with other embodiments of the present invention, power unit **10** and water purification unit **12** may be further integrated by streaming water from the purification unit through the power unit for cooling purposes. The use of source water for cooling presents problems due to the untreated nature of the water. Whereas using the product water requires an added complexity of the system to allow for cooling of the power unit before the purification unit has warmed up to full operating conditions.

[0034] As now described with reference to Fig. 6, embodiments of the present invention provide for monitoring generation device **610**. The term "generation device" is used here inclusively, and may be any distributed utility generation device, such as a water purification system, an electrical generator, or other utility generation device, or a combination of these, as described above.

[0035] In the case in which generation device **610** is a water purification device, source water enters the generation device **610** at inlet **622** and leaves the generation device at outlet **612**. The amount of source water **625** entering generation device **610** and the amount of purified water **613** leaving generation device **610** can be monitored through the use of one or more of a variety of sensors commonly used to determine flow rate, such as sensors for determining the temperature and pressure or a rotometer, located at inlet sensor module **621** and/or at outlet sensor module **611**, either on a per event or cumulative basis. Additionally, the proper functioning of the generation device **610** can be determined by measuring the turbidity, conductivity, and/or temperature at the outlet sensor module **611** and/or the inlet sensor module **621**. Other parameters, such as system usage time or power consumption, either per event or cumulatively, can also be determined. When the location of the system is known, either through direct input of the system location or by the use of a GPS location detector, additional water quality tests may be run based on location, including checks for known local water contaminates, utilizing a variety of detectors, such as standard chemical tests, antibody chip detectors or cell-based detectors. Alternatively, selected water quality and/or quantity and flow rate tests can be run continuously or periodically, regardless of location. Further, scale build-up in the generation device **610**, if any, can be determined by a variety of methods, including monitoring the heat transfer properties of the system or measuring the flow impedance. A variety of other sensors may be used to monitor a variety of other system parameters.

[0036] In the case in which generation device **610** is an electrical generator, either alone or in combination with a water purification device or other device, fuel enters the generation device from a tank, pipe, or other means through fuel inlet **624**. The amount of fuel consumed by generation device **610** can be determined through the use of a fuel sensor **623**, such as a flow sensor. Electricity generated, or in the case of a combined electrical generator and water purification device, excess electricity generated can be accessed through electricity outlet **615**. The amount of electricity used, either per event of cumulatively, may be determined by outlet sensor module **614**. A variety of other sensors may be used to monitor a variety of other system parameters.

[0037] In either of the cases described above, input sensor modules **621** and **623** as well as output sensor modules **611** and **614** may be coupled to a controller **600**, electrically or otherwise, in order to process, concatenate, store, or communicate the output values of the respective sensor modules as now described in the following sections.

Communications

[0038] The sensors described above may be used to monitor and/or record the various parameters described above onboard the generation device **610**, or in an alternative embodiment of the present invention, the generation device **610** may be equipped with a communication system **617**, such as a cellular communication system. More particularly, communication system **617** may be an internal system used solely for communication between the generation device **610** and the monitoring station **620**. In other embodiments of the invention, communication system **617** is a cellular communication system that includes a cellular telephone for general communication through a cellular satellite system **619**. Communication system **617** may additionally include a GPS (Global Positioning System) locator.

[0039] Communication system **617** enables a variety of improvements to the generation device **610**, by enabling communication with a monitoring station **20**. For example, the monitoring station **620** may monitor the location of the generation device **610** to ensure that use in an intended location by an intended user. Additionally, the monitoring station **620** may monitor the amount of water and/or electricity produced, which may allow the calculation of usage charges. Additionally, the determination of the amount of water

and/or electricity produced during a certain period or the cumulative hours of usage during a certain period, allows for the calculation of a preventative maintenance schedule or alternatively system shutdown based on certain parameters. If it is determined that a maintenance call is required, either by the calculation of usage or by the output of any of the sensors used to determine water quality, water quantity, and/or flow rate, the monitoring station **620** can arrange for a maintenance visit. When a GPS locator is used, monitoring station **620** can determine the precise location of the generation device **610** to better facilitate a maintenance visit. The monitoring station **620** can also determine which water quality or other tests and/or monitoring are most appropriate for the present location of the generation device **610**. The communication system **617** can also be used to turn the generation device **610** on or off, to pre-heat the device prior to use, or to deactivate the system in the event the system is relocated without advance warning, such as in the event of theft.

[0040] This information can be advantageously monitored through the use of a web-based utility monitoring system, such as those produced by Teletrol Systems, Inc. of Bedford, New Hampshire.

Distribution

[0041] The use of the monitoring and communication system described above facilitates the use of a variety of utility distribution systems. For example, with reference to Figure 7, an organization **30**, such as a Government agency, non-governmental agency (NGO), or privately funded relief organization, a corporation, or a combination of these, could provide distributed utilities, such as safe drinking water or electricity, to a geographical or political area, such as an entire country. The organization **30** can then establish local distributors **31A**, **31B**, and **31C**. These local distributors could preferably be a monitoring station **620** described above. In one possible arrangement, organization **30** could provide some number of generation devices **610** (shown in Fig. 6) to the local distributor **31A**, etc. In another possible arrangement, the organization **30** could sell, loan, or make other financial arrangements for the distribution of the generation devices **610**. The local distributor **31A**, etc. could then either give these generation devices to operators **32A, 32 B,** etc., or provide the generation devices **610** to the operators though some type of financial arrangement, such as a sale or micro-loan.

[0042] The operator **32A** may provide distributed utilities to a village center, school, hospital, or other group at or near the point of water access. In one preferred embodiment, when the generation device **610** is provided to the operator **32A** by means of a micro-loan, the operator **32A** could charge the end users on a per-unit bases, such as per watt hour in the case of electricity or per liter in the case of purified water. Either the local distributor **31** or the organization **30** may monitor usage and other parameters using one of the communication systems described above. The distributor **31** or the organization **30** could then recoup some of the cost of the generation device **610** or effect repayment of the micro-loan by charging the operator **32** for some portion of the per-unit charges, such as 50%. The communication systems described additionally can be used to deactivate the generation device **610** if the generation device is relocated outside of a pre-set area or if payments are not made in a timely manner. This type of a distribution system may allow the distribution of needed utilities across a significant area quickly, while then allowing for at least the partial recoupment of funds, which, for example, could then be used to develop a similar system in another area.

[0043] The described embodiments of the invention are intended to be merely exemplary and numerous variations and modifications will be apparent to those skilled in the art. All such variations and modifications are intended to be within the scope of the present invention as defined in the appended claims.

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